UNITED STATES DEPARTMENT OF AGRICULTURE
Agriculture Marketing Service

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NATURE AND SCOPE OF COTTON FIBER, GINNING, AND SPINNING RESEARCHES

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INTRODUCTION

In cotton breeding, ginning, and the development and improvement of marketing methods, much emphasis has been given to quality. To measure quality, however, certain standards are required by means of which elements in quality may be compared and evaluated.

The Agricultural Marketing Service is charged with the responsibility of cotton standardization and classification work of the U. S. Department of Agriculture. The requirements for handling this responsibility naturally demand a large number of very closely related and coordinated functions and activities. Among these are: the preparation and distribution of official cotton standards for American cotton; the rendering of a cotton classification service to the public; the supervision of licensed cotton classifiers in this country; the issuance of current cotton quality production statistics; the furnishing of free cotton classing to groups of farmers who organize for cotton improvement; and the operation of an extensive cotton marketing news service.

For the purpose of supporting, reinforcing and improving this cotton regulatory and service work, the Service has found it necessary to carry on current, pertinent and closely related fiber, ginning, spinning, and marketing studies. The researches and the service work are especially designed and conducted so as to complement and supplement each other in a very intimate and mutually helpful way.

Authority for this cotton regulatory, service, and research work is provided by separate and special legislation as follows: 1916, the Cotton Futures Act; 1923, the Cotton Standards Act; 1927, the Cotton Quality Statistics Act; 1930, the Cotton Ginning Act; and 1937, the Amendment to the Cotton Quality Statistics Act, providing free classing of samples to groups of producers who organize for cotton improvement and for more comprehensive cotton marketing news service. Additional authority, of course, is carried in the Department's annual appropriation acts.

Those parts of the fiber and spinning laboratory work which relate more particularly to cotton breeding, production, and improvement programs are conducted in close cooperation with the Bureau of Plant Industry, as will be explained in more detail later. Those parts which are associated more especially with cotton ginning are handled cooperatively with the Bureau of Agricultural Chemistry and Engineering. The engineers of the latter Bureau are responsible for the engineering phases and the technologists of the Agricultural Marketing Service, for the cotton quality aspects.

A large part of the Department's cotton program is conducted in the Southern cotton States through formal or informal cooperation with various agricultural and mechanical colleges, agricultural and engineering experiment stations, private firms and agencies, growers, ginners, classers, shippers, warehousemen, compressmen, and merchants. Contacts also are maintained with various branches of the textile industry including, among others, tire cord and rubber firms; thread manufacturers; and textile schools. Cordial and helpful responses are being received alike from all those concerned in the cotton enterprise ranging from the farmer on the one hand, to the textile manufacturer, on the other.

SETTING OF THE PROBLEMS

In the early days when there were only a few kinds of cotton grown in this country and when the growers of an area generally planted the same variety, cotton was bought and sold largely on a so-called point or regional basis, the particular area where grown having been found to reflect, to some extent, the spinning quality and value of cotton. This accounts for the old usage of such terms as peelers, benders, rivers, creeks, and deltas in describing and identifying cottons. But, with the coming of many new varieties, breeders, commercial ginners, and seedmen, and with the great expansion in cotton acreage and in the size of the crop, the number and complexity of the problems involved in the quality, standardization, and marketing of American cotton multiplied rapidly. Thus, it became evident that some other basis for designating cotton spinning quality and value was necessary.

The Department accepted the challenge and, after considerable study and work of a background nature, established some years ago universal cotton standards for grade and official types for staple length. These are currently being used around the world in the marketing of American cotton. The standards for grade give a basis for the evaluation of color, foreign matter, and preparation; the types for staple length serve as practical guides for the measurement of fiber length.

Copies of the official standards for grade and staple are sold to merchants, manufacturers and others throughout the world to facilitate the

movement of American cotton through international, interstate and intrastate commerce. One of the important problems in the preparation of these physical illustrations of the official standards is to have them uniform and truly representative of the official standards established. One of the important duties of the research workers employed under this project is to check, by laboratory methods, such factors as color and length, more precisely than can be done by the usual methods used in commercial practice in order that the physical copies of the standards offered for sale will be as nearly exact as it is possible to make them.

In addition to the quality factors covered in the official grade and staple standards, there are numerous other fiber properties that affect the spinning quality, value, and marketability of cotton in a very important way. These are commonly lumped together for convenience under the term of "character." However, no official standards have been established for cotton character nor for any of its segments.

Urgent and repeated requests are coming to the Department from spinners, shippers and others of the cotton trade and textile industry, for the establishment of unbiased standards for cotton character. The Department views this as one of its responsibilities in connection with its cotton regulatory and service work. However, the Department does not have an adequate basis for promulgating reliable and practical standards for cotton character nor for establishing accurate and workable classification procedures needed for the successful application of any such standards.

Why is the matter of cotton character and character standards so important? A number of reasons are responsible. Textile manufacturers are finding that different cottons of the same staple length and grade frequently give them appreciable differences in spinning quality and in the quality of their manufactured products. They are discovering that cottons of shorter staple length sometimes give them better spinning results than do longer cottons. They are encountering serious fluctuations in cotton quality from season to season which, in spite of the best classification possible, they are not able to detect until the cotton is spun into yarns. This is "too late."

In particular, many textile manufacturers have made complaints to the Department and to cotton shippers with respect to the American cotton crops of 1931 and 1937. They reported that their yarn and cord strengths were generally down from 5 to 10 percent, sometimes more, and they refer to these as "off years." These shortcomings, however, usually were not indicated nor even suspected on a basis of the most careful classification procedure available; in fact, all reports prior to spinning were to the effect that the cotton was good or better than average in quality. Even upon reexamination of samples of the raw material after the unfavorable spinning results were obtained, cotton classers usually were not able to

detect anything wrong with the cotton. This is no fault of the classers nor of the present standards. On the contrary, it simply means that the classers are not equipped with standards and procedure adequate for recognizing such differences in character and spinning quality.

Presence of such hazards results in all branches of the cotton enterprise carrying on their operations with less efficiency, economy, and success than would be the case if those conditions did not prevail. Moreover, specifications and standards for the products manufactured from cotton are becoming, all the time, more rigid and difficult to meet. This, in turn, makes textile manufacturers more exacting in their selections and requirements of raw cotton. And this, in turn, makes cotton shippers' problems more difficult and their work more uncertain. Thus, manufacturers, shippers, growers, and breeders are struggling "in the dark" with this matter of cotton character.

The lack of official character standards for American raw cotton and of a practical system for classification with respect to character, therefore, are considered serious matters as they affect not only the marketing but the breeding and production of American cotton; as they limit the usefulness of the Department's present cotton grade and staple length standards; as they limit the usefulness of the Department's current grade and staple reports on cotton production and consumption; and as they limit the usefulness of the Department's cotton classification service.

So much for the character problem! Turning now to the subject of staple length, this is a very important matter which offers a large number of specialized and difficult problems. In terms of the laboratory fiber length array, precisely what is the meaning of so-called commercial staple length? For a given fiber length uniformity, what should be the basis for graduations? What should the intervals be? How should the series be pitched? How should different degrees of fiber length uniformity be treated? And so on!

Then, there is the important group of grade standardization problems. More precisely, how far do the different standards for grade actually reflect graduations in spinning quality? Do the standards fit the crop?

How about the matter of "preparation", the degree of roughness or smoothness with which the sample is ginned? Much has been said and written about the subject but very little precise information is available. It is important, nevertheless, for the Department to know the exact nature and importance of preparation in terms of spinning quality; and whether too much or too little emphasis is being attached to this quality element. Some exploratory tests have been made in the laboratories and, while the data are too limited to justify a conclusive statement, the preliminary findings suggest rather definitely that too much importance is now being given to "preparation" as a factor of cotton quality.

With more especial reference to cotton breeding, breeders have often demonstrated that by crossing and selecting they can control to a remarkable degree the size, shape, and fruiting habits of the cotton plant, and the quality of the lint. Breeders frequently assert, moreover, that given the requisite time, they can produce a cotton that will fit closely a stated set of specifications.

Accordingly, in an effort to bring forth superior varieties of cotton that will appeal to manufacturers as well as to producers, breeders frequently ask the question, "What qualities of cotton do spinners want?" At first glance this seems to be a simple and easy question, for which an adequate answer ought to be readily available. But unfortunately this is not the case. Successful cotton manufacturers devote considerable attention to the cottons they buy, and they usually make their selections with care. In nearly all cases, however, the selections are made on the basis of their cotton classer's grade and staple appraisal and on some kind of an opinion with respect to the character of the cotton.

Before an adequate reply can be made as to what qualities of cotton are wanted, two principal things must be done: First, practical and adequate means for measuring the various properties of the fibers must be developed; and second, it must be ascertained how and to what extent these individual fiber properties and combinations of them affect the manufacturing performance and the properties of the yarns and fabrics. Evidently, therefore, in any well-rounded program of investigation of cotton quality, there must be some provision for making these measurements of the properties of the fibers and of their associated spinning quality.

Fiber properties and combinations of them are being appreciably changed through the process of selection and crossing. The organized "one-variety" community development is taking form at a rapid pace, --over a thousand such communities are in operation this season. However, most of the breeding and one-variety-community material is not yet calibrated with respect to precisely measured fiber properties and spinning quality. Therefore, questions arise, such as: What is the present status of American cotton quality? What changes are under way? What changes should be made?

There are many other practical problems and questions that are of importance to cotton marketing and production and on which precise information is needed, such as: How does the quality of cotton grown under irrigation in the Southwest compare with that of rain-grown cotton in the main Cotton Belt and are quality differences due to irrigation or other factors? What are the reasons for the relatively poor spinning quality of the 1937 crop, and the 1931 crop, reported by so many spinners? Are the differences real or only apparent? What is the new Sea Island like? How does the new Sakel X Pima cotton compare with Pima? What effect does speed of gin saws have on the quality of cotton? Is the quality of lint picked with new cotton picking machines as good as that of hand-picked cotton? What happens to the

spinning quality of cotton if the fibers in the bale are highly immature? What is the best temperature at which to operate the recently developed cotton driers now being used at so many gins? Does storage affect the spinning quality of cotton? Are the fibers injured when the bale is compressed to "high density"? How does the cotton being used in the so-called export program "stack up" with respect to quality?

Information along the lines suggested, plus the development of more rapid and practical technique and apparatus for making the needed measurements and comparisons, is basic to the development of more efficient and orderly marketing of cotton. These developments are, therefore, essential to the conduct of the work on cotton quality standardization and classification for which the Agricultural Marketing Service is responsible. Also, as competition between world growths of cotton becomes keener; as the requirements for the service performance of products manufactured from cotton become more rigid and exacting; and as the properties of cotton fibers and lint are changed through the processes of selection, hybridization, and cultural methods, it is equally as essential that information, concepts, and techniques along these lines be developed with technical and mathematical precision. In other words, all of this is needed if cotton quality and its components are to be thoroughly recognized and standardized; if bales of precisely like quality are to be assembled into even running lots; if rejections and acceptances are to be made with more certainty; if cottons best suited to the technical requirements of specific uses are to be supplied.

NATURE AND SCOPE OF RESEARCH PROGRAM

With the foregoing problems and challenges in mind, the cotton quality and standardization research program of the Agricultural Marketing Service has been developed. The technical fiber, ginning, and spinning researches, therefore, constitute a very vital part of the broad Federal-State cotton program.

The principal problems involved in cotton quality research, their relationships and ramifications, and the factors and elements associated with cotton fiber, yarn, and fabric quality are illustrated in the two charts at the end of this paper.

The research program involves a group of technical facilities in Washington and in the field and, roughly speaking, the number of laboratories and people are about equally divided between the two. A number of project leaders, supported by professional, subprofessional, and clerical assistants, conduct studies and tests in the various laboratories on the properties of cotton fibers, seed cotton, yarns and fabrics; on methods of

measuring the various quality properties and of giving expression to them; and on conditions under which the tests are and should be made.

There are about 100 persons working full-time in the various fiber, ginning, and spinning laboratories. About 60 of them are employed by the Agricultural Marketing Service; around 20 have been assigned to the fiber and spinning laboratories by the Bureau of Plant Industry; and 18 are on the staff of the Bureau of Agricultural Chemistry and Engineering in connection with the ginning investigations. Some parts of the work also require a sizable number of laborers and seasonal temporary employees.

The numerical size of the staff associated with the Department's cotton fiber, ginning, and spinning laboratories may look large. However, considering the importance of cotton as a national commodity, as the principal commodity of Southern agriculture, and as a factor in international commerce, the size of the laboratory staff properly may be considered relatively small; more especially so when it is compared with the cotton laboratory staff in certain foreign countries. The Shirley Institute, which is composed of a large number of technical laboratories and which is supported by the British Government and the English textile industry, and the technological laboratories of the Indian Central Cotton Committee, which are supported by the Indian and British Governments, are both reported to have staffs working on problems of cotton fiber and related manufacturing quality considerably larger than ours. Too, under the auspices of their respective governments, Brazil, Argentina, and other South American countries are making appreciable progress in the development of laboratory facilities, personnel, and work with respect to their cottons.

Included in our group of laboratories in which work is being done on segments of the same problems and, in many instances, on the same samples, are physical, chemical, X-ray, and microscopic laboratories in Washington; spinning and weaving, yarn and fabric testing laboratories at Clemson, S.C., in cooperation with the Clemson Agricultural College; fiber, spinning, yarn and fabric testing laboratories at College Station, Tex., in cooperation with the Texas A. & M. College; and ginning, classing and related fiber laboratories at Stoneville, Miss.

Specifically, it is the purpose of the fiber studies to (1) relate the various fiber properties to the more fundamental physical constants, (2) find the relations between the fiber properties and the properties of the manufactured products, (3) provide more rapid and practicable methods for recognition of the properties and comparison of the standards and (4) supply more accurate controls for graduation, establishment, and reproduction of the standards. It is the purpose of other studies to find out how

to improve the properties through breeding and cultural methods; how to retain them in the cotton through proper ginning; and how to utilize them most effectively in manufacture.

The Department's first and foremost interest is agriculture and farmers. In the past, cotton manufacturers not infrequently have said that the laboratories and the Department of Agriculture help only the cotton producers and do nothing for the manufacturers. Of course, that is incorrect because-- by assisting the farmer to grow better cotton and by making possible more accurate quality standards, a better classification service, more reliable quality statistics, more effective market news, and more timely price quotations--the work and accomplishments are also of very definite practical benefit to the manufacturer. Moreover, a number of special developments from the technical laboratories and investigations are of direct value not only to the cotton textile industry, in general, but also to the cotton mill manufacturers, in particular. Comments and reactions that are coming to the Department give good evidence that cotton mill men and others are realizing and appreciating these facts more and more. For example, key persons in the cotton textile industry and in cotton agriculture are coming together more and more. In the last few years there seems to have been a keen awakening on the part of many that both groups have many problems in common. This is viewed as a wholesome and encouraging development and one reflective of progress in a constructive direction.

The Department cannot be interested in cotton agriculture and cotton farmers in a way and to the extent that it properly should unless it also is interested in all persons, groups, agencies, and welfares involved in the entire cotton enterprise, that is, ginners, shippers, distributors, manufacturers, consumers, etc. Therefore, in order for the Department to serve Southern agriculture and cotton farmers most efficiently and effectively, all of its thinking and transactions associated with the program must be as unbiased and impartial as possible. Strict adherence to principles, properties, mechanisms and relationships must be followed and every effort must be made to reduce, if not eliminate, the personal equation. Certainly, anything short of this would be unjustifiable on the part of any staff member and incompatible with the responsibilities and confidence that have been imposed in each agency, subdivision and individual.

PRINCIPAL LINES OF LABORATORY WORK

Through close cooperation with the Bureau of Plant Industry, samples of cotton of known variety and of known planting, growth, and harvesting history are made available for many of the researches. It is essential to have this information, if the reasons for certain fiber and spinning differences observed in the laboratories are to be explained. Because, before we can

produce consistently better cotton that meets the spinners' requirements and before we can more effectively classify, standardize and market the material, we must know precisely in terms of fiber properties, better than we now know, what it is that makes the good cottons good, and the bad cottons bad.

With the present set-up, the work is made more effective and comprehensive since detailed and complete records are made as to the case histories of the samples. These cover such points as: soil type and fertilizer; date of planting and seedling emergence; nature and rate of plant growth; flowering and fruiting habits; date and rate of boll opening; nature and extent of cultivation; occurrence and amount of rain and sunshine; soil and air temperatures; date and method of harvesting and ginning; yield, gin turn-out, lint percentage, lint index; and the like. Information of this type is needed as a background to show the conditions or causes responsible for the various physical and chemical properties of the fiber and whether they are the result of hereditary, environment, or method of handling. With such information, too, the results are more likely to have practical value since the facts revealed can be used as the basis for choosing the varieties, soil types, and general climatic conditions most suitable for the production of cottons containing the properties most desired for any specific purpose.

Cotton fibers vary widely in their individual and combined properties. The properties of the fiber, of course, are dependent, first, on the composition, that is, the relative proportions of cellulose and other constituents, and second, on the way in which the constituents are combined, that is, the structure. Obviously, the cellulose as the principal constituent of the fiber is of prime importance although its properties, behavior, and over-all reactions are modified more or less by the small amounts of other constituents present.

Investigations are being conducted at the laboratories at Stoneville, Miss. into the ginning or separation of the fibers from the seeds. These studies involve such fundamental problems as the mechanical effects of the conditioning, extracting, cleaning, and ginning processes on cotton quality; the influence of light, temperature and moisture on the fiber while exposed in the field; and the changes in the seeds that may occur during storage due to fermentations and micro-organisms. The studies also include those problems relating to the strength of attachment of the fiber to the seed as influenced by variety and condition of growth; various fiber abnormalities and imperfections as neps and naps; and various non-fiber inclusions such as motes and seed coat fragments.

Physical studies are being conducted in the laboratories at Washington, on fiber length and length variability; fineness on both geometric and mass bases, degree of cell wall development or "maturity," wall conformation and

structure, surface and frictional phenomena, strength, color, and related properties. A major portion of the work is devoted to developing suitable indices or measures of these properties, designing and developing new and more rapid test methods, detecting and measuring the interrelationships of these properties, evaluating the importance of the different properties, and seeking practical methods for classifying cotton according to its various attributes. The properties of cellulose enter into and circumscribe the physical properties of cotton lint but these are modified to a greater or lesser extent by accompanying non-cellulose constituents.

Studies involving chemical and related technique are conducted in the laboratories at Washington to support and explain the physical behavior of different qualities of cotton lint, to disclose the crystalline-fine structure through application of X-ray techniques, to provide convenient measures of certain physical properties and to disclose variations in composition brought about by genetic, growth, or destructive agencies. Samples are subjected to chemical tests, including fluidity, copper number, methyline blue absorption, wax content, and may be studied under polarized and fluorescent lights.

While at one end of the program, ginning studies are being conducted to determine the influence of the ginning processes on the quality of raw cotton, at the other end, our laboratories are conducting spinning studies, in South Carolina and Texas, to determine the influence of the various cotton fiber and lint properties on their manufacturing behavior and on the quality and value of various products manufactured from them. Spinning and other textile manufacturing processes are considered a vital part of our cotton quality program since almost no cotton is used in the raw or unmanufactured condition. It is, therefore, only by actual conversion through the processes of manufacture and by measurement of the properties of the products so manufactured that evaluation can be made of the effect and importance of different individual fiber properties and combinations of them as well as other quality aspects of a raw cotton.

The investigations relating more particularly to the origin, growth and development of cotton fibers, previously conducted in our laboratories at Washington and at the Boyce Thompson Institute, Yonkers, N. Y., are now under the leadership of the Bureau of Plant Industry. That Bureau has a small group of cytologists and microscopists working in its laboratory at Raleigh, N. C., in cooperation with the North Carolina State Agricultural College and Experiment Station. Other tests of a physical, X-ray, chemical and spinning nature are being made on these special samples to the extent that the quantity of material available permits.

This gives a cross-sectional picture of some of the work that is being done to study cotton quality in the Department's various technical laboratories. It should be emphasized, however, that no one fiber property ought to be viewed as an unvarying index of cotton quality. The cotton with the longest or strongest or finest fibers, or the smallest proportion of thin-walled fibers, does not always produce the strongest yarn or serve better than another cotton for a particular purpose. In the first place, there are numerous interactions among the several properties, that produce varying effects and that are difficult to predict. In the second place, the different uses to which the manufactured products are to be put require different combinations of properties. That is, a cotton which is best for a balloon fabric because of the high strength of its yarns may not be desirable for terry towelling, which requires a fluffy, resilient yarn.

It follows, therefore, that no one fiber test can give a measure of the over-all spinning value of a cotton. Many letters are received from persons who seem to feel that the polarizing microscope, or the X-ray machine, or the Chandler bundle tester will, by itself, give a complete picture of the spinning performance and the value of a sample. That this is not true is clear when the function of a particular fiber test is understood and the importance of a number of different fiber properties is appreciated.

To obtain a reliable measure of the over-all spinning value of a cotton, it is necessary to subject it to a spinning or manufacturing test. This usually consists of spinning the sample into yarns and possibly twisting them into cords or knitting or weaving them into cloth.

Many people who are interested directly or indirectly in cotton quality have an erroneous impression of the spinning test, in that they believe it is the complete solution of the problem of measuring cotton quality. They believe it is a simple matter to determine what a cotton really is and can do, just by making it perform. This would probably be true if one had the time, patience, money, and the quantity of cotton to test it out over a wide range of conditions. As this is out of the question, we usually must be content with one complete test, sometimes duplicates, carefully conducted under controlled conditions (with respect to manufacturing organization, speeds, settings, and atmospheric conditions). Effort is made, too, to have these things as nearly typical and representative as possible of those under which the cotton would be manufactured in a commercial plant in order that the results obtained will have the fullest significance as to problems and commercial conditions.

A part of the work is directed at the development of more accurate methods of determining spinning quality from the results of fiber tests

alone. Although considerable progress has been made in this direction, and occasionally fiber tests can be made to supplant spinning tests, for the most part sufficient fiber tests cannot yet be made cheaply enough, nor the predictions accurately enough to justify a large-scale substitution.

At the present time, the industry is undergoing slow but certain changes in various manufacturing processes and in design and construction of manufactured products. As these changes are effected, present-day concepts of the relative importance of some of the physical properties of the fibers doubtless will change. Thus, to keep pace with these changing and demanding circumstances, the spinning and manufacturing phases of the work will likewise have to be continued.

CLASSIFICATION

Federal cotton classers classify representative samples of all lots of cotton used in the fiber, ginning and spinning researches. In many instances, special technique from the standpoint of comparative classification between samples is employed. They examine and study the samples of cotton, calibrated with respect to one or more fiber properties, with a view of possible improvement in classification technique and concepts.

Specialists of the classing rooms and technologists of the laboratories work together on their common and closely related problems. The information and criticism supplied by each group give practical point and effect to that furnished by the other. Moreover, coordinated effort and correlated data have additional advantages in that they make it possible to simplify and expedite the handling of many problems of an administrative nature which are involved in cotton standardization, classification, and market news work.

SOME PROGRESS AND ACCOMPLISHMENTS

A discussion of the fiber and spinning properties and relationships for different cottons and growth conditions involved in the Regional Variety series will be presented in several papers at a later session of these meetings. It is only necessary, therefore, to say that this study is the most comprehensive of its kind thus far attempted and embraces a wide range of material of known case history: 16 outstanding varieties, grown at 14 stations across the rainfall part of the Cotton Belt, 8 replications of each variety at each station, and for the 3 crop years 1935, 1936, and 1937. Also, 7 varieties grown at 4 points in the Southwestern irrigated region are included. The proposed laboratory work on these samples is about two-thirds completed and some very interesting and promising findings already have been discovered in reference to principles, mechanisms, and relationships involved in cotton breeding and production.

Certain developments from other laboratory work may be listed in a more or less itemized fashion as follows:

Cotton Color and Light Studies

A disk colorimeter, developed for measuring the color of cotton and other farm products, is now widely used in other fields. The machine makes it possible to express results of color measurements in units directly comparable with what the classer sees and thus to relate results of laboratory experiment directly to practical experience.

By such means, color records of the grade standards have been established and it is now possible: (1) To make and to keep the standards more nearly constant; (2) to see how closely individual or committee classers keep to the standards or to each other; and (3) to know the direction and amount of their variation.

Color surveys of several crops have been made and the information obtained, together with observations made by cotton classers and others has been of assistance in discovering that the Universal Standards for Grade did not properly fit the crop. Appropriate revision in which the laboratory color work and data played a helpful part recently has been made of these grade standards.

An instrument for automatically scanning the surface of a cotton sample by means of a photoelectric cell hook-up is in the process of development. It will make possible the analysis and recording of the three grade factors: color, leaf, and preparation. Elimination of the personal equation from grading is important.

Light measurements have been made in the Service's various classing rooms over the country and specifications have been developed for satisfactory artificial daylight conditions for cotton classing. An artificial daylight installation has been made in the color laboratory in Washington and new smaller units are being installed for trials elsewhere by private concerns. These new developments promise to reduce the errors of cotton grading and to speed up the work of cotton classing.

Other Physical Studies of Cotton Fiber Properties

A duplex cotton fiber sorting machine has been developed. The application of this technique is making it possible for the laboratories to render valuable aid in connection with the staple standards and to cotton classers, breeders, manufacturers and others. Data have been developed for each of the bales promulgated as standards for staple length as regards fiber length distribution, including mean length, upper quartile length, coefficient of variability, and other statistical values.

Similar tests have been and are being made on new or copy bales for possible use in making up the staple length types that are sold to the public. Tests are made also on staple length types returned or about which complaints or questions have arisen. On the basis of facts brought out as compared with those for the originally promulgated bales, a more refined comparison is made of the copy bales and the returned types than is possible by the cotton classifiers stapling process alone. The technical data revealed, not to speak of the diminishing number of complaints received, indicate that the classers' stapling procedures and selections are becoming more accurate and stable; also, that the fiber length pattern in the selected copy bales from which types are made and sold are matching more closely those of the promulgated bales.

An outstanding contribution has been the development and improvement during the last few years of the so-called Chandler Bundle method for determining the strength of cotton fibers. The method is unique and the data obtained from this strength test posses more significance, in terms of yarn and spinning quality, than data from any other known strength test insofar as we know. A relatively high correlation now is found to exist between fiber strength and yarn strength. Moreover, a number of research and testing laboratories in the textile industry and in agriculture are using the method and finding the information to be applicable and helpful.

Special studies in reference to fiber immaturity have been made on selected samples of extremely low-grade and poor-character cotton under review by the Appeal Board. The laboratory findings have been helpful to the classers in appraising the relative merits and demerits of boderline and questionable samples. Classification problems of this kind are extremely difficult to handle but they are, nevertheless, of importance from the standpoint of tenderability on futures contract and of government loans.

A special technique has been developed for the quick cross-sectioning of cotton fibers. This permits important information to be ascertained rapidly on the area and shape of cotton fibers within a particular sample and between samples. Many samples have been tested and the data accumulated have given a basis for developing definitions, graduations, and tolerances. Good progress is being made toward the development of a qualitative method for comparing cottons more rapidly than ever before, as to fiber fineness and associated cross-sectional features. These properties appear to be of much importance in cotton character.

Numerous methods of a more rapid and practicable nature for measuring other properties of cotton fibers are under development. Progress is being made with a photoelectric hook-up for more quickly measuring and simultaneously recording the properties of fiber lengths and their uniformity. With such a development, the laboratories can be of still greater and more practical service in the preparation of standards, and to cotton classers and breeders by checking the quality and by helping them to decide the quality in important, critical, or questionable cases. It is not expected, however, that such a laboratory device will take the place of cotton classers. Classers perform a very definite and important function and, insofar as we can see, they will be needed at least for a long time to come.

Chemical and X-Ray Studies

A method for measuring and comparing the X-ray patterns of raw cotton has been developed and refined and progress has been made in establishing a basis for predicting the strength of raw cotton rapidly by an X-ray technique. A photoelectric photometer has been designed and constructed for reading the X-ray patterns. Although this instrument was essential in the adaptation of the X-ray technique for the measurement of X-ray patterns with raw cotton, it has other important applications. Some distinct advantages are offered by the new method over the usual strength tests.

Preliminary studies have shown a fairly close relationship between the strength of cotton fibers and the fluidity of their solutions. As a result, some new practical methods of testing appear in the making.

The changes that take place in raw cotton during growth of the cell wall are being studied, as a basis of developing a more rapid and practicable method for measuring cotton fiber maturity. It has been found that, during the fiber growth process, the sugar content decreases from about 60 percent to approximately 2 percent; other constituents likewise change. Thus, the development of a new fiber test of importance to cotton character standardization seems bright.

The degree of deterioration of raw cotton of various growths and case histories of harvesting, storage, and marketing is being measured by numerous laboratory devices. Cotton is known to develop spots and change color after ginning. The extent of such deterioration, especially that caused by microorganisms, is often considerable but its true importance with respect to character and spinning quality is not known at present.

A study is being made of the relation of moisture to cotton fiber, particularly with respect to rapid techniques for measurement, methods of diffusion or migration, and explanation of its important influences on the fiber properties and their stability. Work of this type is slow and laborious; however, progress is being made.

Cotton Ginning Studies

A series of horizontal and vertical types of hot air driers for use with damp or wet seed cotton has been developed at the Stoneville ginning laboratories. As an outgrowth of this work more than 800 driers were reported in operation throughout the Cotton Belt last season and it is estimated that they were used in ginning more than 1,000,000 bales of cotton. Attention is now being given to designing cheaper drying units, in an effort to make the drying service available to more growers throughout the Belt.

Tests made on a large number and on a wide range of seed cottons have shown that the use of the drier, when properly operated, improves the grade

and market value of cotton to an extent that the monetary benefits average 70 cents to $2.50 per bale. Many individual cases show considerably greater benefits from drying. Thus, cotton farmers and the South reaped between one and two million dollars last year which would have been lost if their cotton had not been artificially dried.

Testing, during the last 6 years, of commercial types and makes of cotton cleaning, extracting, and ginning equipment has resulted in the establishment of optimum combinations of machines and of machine settings. Contrary to popular belief, it has been demonstrated that the use of the most elaborate and complex cleaning and extracting equipment available today will not produce, from roughly harvested seed cotton, ginned lint of a quality comparable with that obtained from minimum cleaning equipment on carefully hand-picked seed cotton.

Research on questions of saw tooth, pitch, shape, and fineness has provided a basis and indicated means for attaining better ginning capacity with loose seed rolls while at the same time preserving the quality of the cotton.

Various types of instruments and apparatus have been developed for checking various details involved in ginning and for promoting better ginning. Among these are: foreign matter fractionater; air velocity meter for use with air blast gins; moisture indicator for seed cotton; small gins for extremely small samples and special laboratory tests; gin attachment for culling or sorting seed cotton and removing immature, frost-bitten, or insect-damaged locks.

A laboratory system has been developed for classifying different kinds of imperfections in ginned lint and rating samples accordingly. Such imperfections cause an increase in manufacturing waste or imperfections in yarn and fabric, or both. The extent to which these imperfections occur in ginned lint has been found to be related to: characteristics of the seed cotton (largely varietal, although modified to some extent by environment), moisture content of seed cotton at time of ginning, and treatment during ginning. Since these imperfections affect the cost of manufacture, bleaching and dyeing, and the number of "seconds", it is important that they be eliminated whenever possible.

Seed coat fragments in cotton lint are undesirable and can be very troublesome to a manufacturer. Recent studies have given considerable information on the causes of seed coat chipping during ginning. It has been found that the degree to which these fragments appear depends to the greatest extent, by far, upon the variety of cotton. For example, for 16 important

varieties grown at one place, there has been found a range of seed chipping from 0.3 percent to 23.0 percent and the chipping of the most susceptible variety was approximately 75 times that of the least susceptible.

The time and energy consumed in ginning have been found to be affected appreciably by the size and fuzziness of the seed and by the lint turn-out. The studies of various seed cotton characteristics that influence ginning efficiency, preparation, and quality of ginned lint are being continued. Cotton should be bred and produced with inherently high ginning quality no less than with high spinning performance.

Progress is being made in the development of practical methods for overcoming bale plating at the gin and for preventing the mixing of seed cotton during ginning.

Studies are being made in connection with bale compression, including so-called air cutting, size, shape, density, wrapping, etc., of bales. Progress is being made with the development of a device for mechanically sampling cotton during the process of ginning, and a bale marker has been developed which will permanently identify bales through the channels of trade.

Cotton Spinning Studies

A method has been developed for obtaining reliable spinning test results from samples of cotton as small as two pounds. This is important in that it is of direct interest and application to cotton breeding and standardization work, through savings in materials, money, time, and effort.

A miniature slasher employing some new principles has been developed which, with a small scale loom recently obtained, makes it possible to weave a sufficient quantity of fabric from a sample as small as 5 pounds for testing and for providing more complete information on manufacturing, dyeing and finishing properties. Thus, weaving and related testing can now become a routine part of the spinning tests thereby extending our field of knowledge.

Benchmarks have been developed from accumulated data for determining relative waste and yarn strength to be expected on the average of cotton of any grade and staple length. This provides a practical basis for quickly determining the rank of any sample.

Standards for cotton yarn appearance have been devised. These provide a much-needed basis for grading cotton yarn as to uniformity or evenness and freedom from imperfections. Thus, it is now possible to give a more comprehensive picture of the spinning quality of cotton than ever before. Through this development principally, it has been discovered that cotton varieties vary appreciably in the degree of smoothness or roughness with which their yarns are characterized; also, that yarn evenness is far more a function of variety and genetics than heretofore has been known or suspected.

Experiments have demonstrated the importance, hitherto not fully recognized, of fineness as an element of fiber character. The laboratories have found that long, fine-fibered Sea Island cotton cut to shorter lengths has given yarns about 50 percent stronger than does natural grown American cotton of like staple length. With this lead we searched for and found a fine-fibered cotton of only about 3/4 inch in staple length which has given yarn strength comparable with that usually obtained from 1-1/8 inch Delta cotton. This very short but fine cotton has been crossed with an American variety of longer staple length and better yielding qualities. The resulting hybrid averages around 1-1/8 inch staple length and has given yarn strength in line with that usually furnished by cotton of 1-1/2 inch staple length.

Samples having extremes of fiber fineness and coarseness even from a single commercial variety of cotton have given results which breeders and manufacturers call "amazing". A fine-fibered cotton gave yarns averaging 25 percent stronger than a coarse cotton. This difference in favor of the fine cotton is even more outstanding since the fine cotton was somewhat shorter than the coarse. Yarns from the fine cotton were nearly 20 percent stronger than those from the general run of cotton of like staple length; yarns from the coarse cotton were about 5 percent weaker than those from the average cotton of like staple length. And, the fine cotton was consistently better than the coarse cotton from every other spinning standpoint, as: wastiness, behavior during processing, and yarn smoothness.

Reduction in cost of cotton production and manufacture is a very important factor in the interest of American cotton and American cotton farmers. Fine-fibered cotton requires less twist per inch of yarn to give maximum yarn strength than does coarse-fibered cotton. Other things being equal, therefore, the finer the cotton the less the cost of manufacture. Naturally this factor has great appeal to textile manufacturers.

As a result of these findings, breeding experiments and selections are going forward in various parts of the Cotton Belt to produce fine-fibered cottons of medium and short staple length, with appreciable progress.

The influence upon cotton spinning quality has been determined for changes in such ginning factors as: moisture content of seed cotton; seed roll density; number of saws; number, size, and shape of saw teeth; speed of saws; type and number of cleaners. This information has made possible special developments and recommendations, at the ginning laboratories, for commercial ginning of benefit to American cotton and of interest to cotton farmers.

For cottons of about 1-1/4 inch staple length, saw ginning has been found to produce lint with better spinning quality than roller ginning.

Preliminary information has been obtained that indicates the need for possible revision in certain concepts relating to the importance of preparation as an element of cotton quality. Additional studies are being carried on.

The frequently recommended practice of sun drying of seed cotton before ginning has been found to reduce materially the spinning quality of the lint even though it tends to give samples with smoother preparation; that is, it causes a decided increase in spinning waste (principally comber waste) and an appreciable loss in yarn strength. Artificial drying, when properly done, has been found to give samples with a relatively smooth preparation but without any material loss in the spinning quality.

Many complaints have been received from manufacturers regarding the quality of the 1937 cotton crop. Laboratory spinning tests of a number of selected varieties grown at various locations across the Cotton Belt have largely confirmed these complaints. To illustrate: for two varieties grown at 11 locations, the average yarn strength in 1937 was 8.1 percent weaker than that in 1936. The longer variety decreased 9.6 percent, and the shorter, 7.0 percent. At one location, the two varieties were 25 percent and 36 percent weaker, respectively, in 1937 than in 1936. However, at four locations, one or both of the varieties produced stronger yarn in 1937 than in 1936. A study of the fiber data for these cottons is now being made, together with the case histories of the samples. The findings and relationships are proving most interesting and valuable and they are expected to explain the relatively poor quality of these and other cottons in 1937.

The spinning and fiber data for the Regional Variety Series have been reported to the Bureau of Plant Industry, as rapidly as they became available, for assistance in its work and recommendations. The laboratory tests are being pushed to completion as quickly as possible but the task is a large order. Some important findings and relationships, nevertheless, have already been yielded by the laboratory work, as will be discussed by others on a later program during these meetings.

In connection with the regional variety work completed to date, one outstanding fact has been brought out, namely, one popular variety gave relatively poor results for cotton of its staple length, at most of the locations. Further investigation has shown that a considerable proportion of the cotton grown in Texas is of this variety or somewhat closely related to it. It is possible, therefore, that this finding is a partial explanation of the many complaints that the Department has received from manufacturers, principally foreign ones, during the last few years regarding the quality of Texas cotton.

Obviously, the fiber and spinning information obtained from the regional variety studies will be valuable to representatives of the Federal and State agencies and to other persons in making certain decisions as to cotton breeding and production. It will also assist the cotton growers in the approximately 1,000 one-variety communities that now exist and in those that follow, to grow the cotton that has the best spinning value for local growth conditions and for the principal textile requirements.

PUBLICATIONS

Many of the results from the cotton fiber, ginning, and spinning studies are of a specialized and technical nature. Thus, before they can be used by agricultural research and extension workers, it is necessary for the staff of the laboratories to "translate" the data into an appropriate and manageable form that can be used by these workers. Proper interpretations and conclusions depend to a considerable extent upon familiarity with the technical background of problem, material, case history, method of test, and purpose.

Usually, as soon as laboratory analyses have been completed, the findings are made available in the form of preliminary reports to the administrators and specialists concerned with the cotton standardization and classification work of the Agricultural Marketing Service; to the specialists of the Bureau of Plant Industry responsible for the cotton breeding, production, and improvement programs; and to State or private cotton breeders, agronomists, ginning specialists, spinners, and others who use the data to guide them in their work.

Later, depending upon the progress made, the needs to be served and general interest, the results of the fiber, ginning and spinning studies are published in Departmental publications of a technical, semi-technical or popular form.

Technical discussions are contributed to "outside" scientific and technical journals. Many articles also are currently released through various agricultural papers as well as periodicals in the fiels of cotton ginning, trade, and textiles. News items frequently are furnished on timely and seasonal subjects to daily and weekly papers, principally those that serve the cotton States.

A gratifying number of contributions based upon the cotton quality and standardization researches have appeared during the last 12 years, 1927-1939. A number of manuscripts are now in various stages of preparation for publication. Counting the Departmental publications, articles in outside journals, and those in various agricultural, trade, and ginning periodicals, a total of well over 200 releases have appeared.

EXTENSION

Effective and more prompt dissemination of the highly specialized findings and/or information on technique developed in the laboratories is given by direct personal contact. That is, upon invitation, the different technologists and engineers give frequent speeches before interested groups and meetings of agricultural workers, cotton farmers, ginners, textile people, scientists, and others.

Also, from time to time, persons who are connected with other Federal, State, and private agencies and who are concerned with cotton problems make visits to the laboratories to obtain information and help.

In connection with the cotton market news service, seasonal and practical cotton problems are discussed over the radio, as far as practicable, including the work and findings of the various technical laboratories in Washington and the field.

The Federal-State Extension Service is playing an active and helpful part in further disseminating the findings and recommendations, particularly the ginning investigations. The interest and cooperation which the Extension Service and its workers are giving to the cotton research program and to the staff engaged on it is commendable.

An active gin extension program has been developed for making more practically effective the research findings. There are now about 15 persons engaged in this work in 11 States. Two training schools have been held for these specialists at the ginning laboratories, and conferences have been held elsewhere with various groups. Progress is being made and the future promises even greater strides. Manufacturers of ginning equipment are cooperating effectively, in making changes in design, construction, and operation of their machinery as the findings indicate desirable. The net effect of all this is the promotion of better ginning and help to cotton farmers and ginners.

CONCLUSION

The foregoing gives a general picture of the cotton fiber, ginning, spinning, and related researches of the Agricultural Marketing Service, and briefly touches on their relationship to some of the work of other agencies.

The cotton standardization and classification work with which the Service is charged, the setting of the problems, the problems themselves, the nature and scope of the researches, and the principal lines of laboratory work all give evidence of the degree to which the cotton regulatory and service work and the coordinated laboratory researches complement and supplement each other. Viewing the activities as a whole, they also emphasize the necessity for the close "tie-in" of the several lines of work, if the results of research are to be effectively applied to the practical problems of cotton standardization, classification, and marketing, on the one hand, and to those of cotton breeding, production, and improvement programs, on the other.

Emphasis has been given to the complex and difficult standardization and classification problem involved in cotton character and to the need for its early solution. Progress is being made in the laboratories on this problem, but much painstaking study and work remain to be done.

The ultimate goal is the development of practical standards for cotton character and of appropriate classing technique to make effective their application. Until that goal is reached, the laboratory information now being accumulated on the quality of selected varieties and growth conditions seems likely to be of valuable assistance in connection with the marketing of American cotton. That is, with such spinning and fiber data as a background, plus information as to variety, geographical point of growth, grade and staple length, together with permanent bale identification, it should be possible for shippers and manufacturers to make selections and rejections in reference to certain character categories and so to assemble "even" running lots of bales on a basis of character. Consideration is being given to this method of approach and definite progress is being made in certain one-variety communities.

The final test of quality of any cotton is, of course, its spinning value. That is, what will it produce in the cotton mill? And at what cost? The final explanation of the spinning quality of any cotton and of differences in spinning value between cottons depends upon the combination of properties that characterize the fibers, singly and in mass, and upon the nature and extent of any foreign matter present among the fibers.

Answers to these questions are being sought by the Agricultural Marketing Service in its fiber and spinning research laboratories located in Washington and in the South and through cooperation with the Bureau of Plant Industry, the Bureau of Agricultural Chemistry and Engineering, and various Southern agricultural colleges and experiment stations. Intensive and extensive tests are being made of leading American varieties of cotton to determine their relative spinning quality and value, and the influence of soil, climate, and seasonal differences on the fiber and spinning properties of such cottons.

Heretofore, in the absence of adequate knowledge and technique, private, State, and Federal agencies concerned with the breeding and production of American cotton necessarily have had to formulate certain concepts more or less "in the dark" and to proceed as best they could. It is understandable, therefore, why some of the previous recommendations and operations have had to be predicated on assumptions. However, laboratory findings already obtained and expected in the near future should be of valuable assistance to the more intelligent shaping of our national and State cotton marketing, production, and improvement programs.

Too, on a basis of the laboratory findings which are being obtained, it is felt that the competitive position of American cotton in foreign and domestic markets would be improved to the degree that character elements can be bred into the crop and to the extent that character differences can be recognized. The combination of fiber properties desired will depend, of course, upon the varying requirements of the manufactured product.

Another step that needs to be taken to round out the present program is a similar study of typical varieties of cottons from foreign countries. Direct comparisons would show which foreign cottons, if any, are superior to American cottons and what they have that make them superior. Information of this type would be of value to the marketing of American cotton in world markets and to the cotton breeding and production program of this country.

Still another step that needs to be taken is the testing from year to year of the principal varieties of American upland cotton grown at selected points across the Belt and the issuance of prompt reports each season on the spinning and fiber measurements. These data would give a more adequate basis for detecting fluctuations and instability of varieties and growth conditions and for making more intelligent selections and rejections with respect to cotton breeding, one-variety community, and improvement programs. The ultimate goal, of course, would be to advise the textile industry and the cotton trade as to available supplies and sources of raw cotton with specified fiber and spinning properties.

A final step that needs to be taken to complete the present program is routine fiber and spinning tests as a direct service to cotton breeders and others. Nowhere in this country is there any provision for a laboratory service of this type even though the needs are urgent and the opportunity is great. The Agricultural Marketing Service is authorized to render a cotton classification service to the public, on fee basis per sample, and gratis basis to groups of cotton farmers who organize for cotton improvement. However, it does not have the facilities and personnel needed for making spinning and fiber tests of a public service nature.

During the last few years, our laboratories have received many requests from private cotton breeders and other agencies for laboratory service tests on their new selections, crossing, strains and commercial types of cotton. The request are becoming more frequent and insistent because of recognition by cotton breeders and other persons in the agricultural and industrial fields that they urgently need information of this character for better handling their own practical problems and work. They are also realizing more and more that the expense, time, equipment, and personnel involved automatically prohibit them from undertaking such tests; and that more knowledge and experience than they possess are required as a background if the comparisons, interpretations, and conclusions are to be most effective. Obviously, other advantages from having such a service testing laboratory to operate in conjunction with closely related research laboratories would be that the data obtained from the service tests would greatly strengthen the research program and that, should the number of requests fluctuate below the normal capacity of the service testing laboratory at any time, its facilities could be used for the time being to advantage on related problems of research.

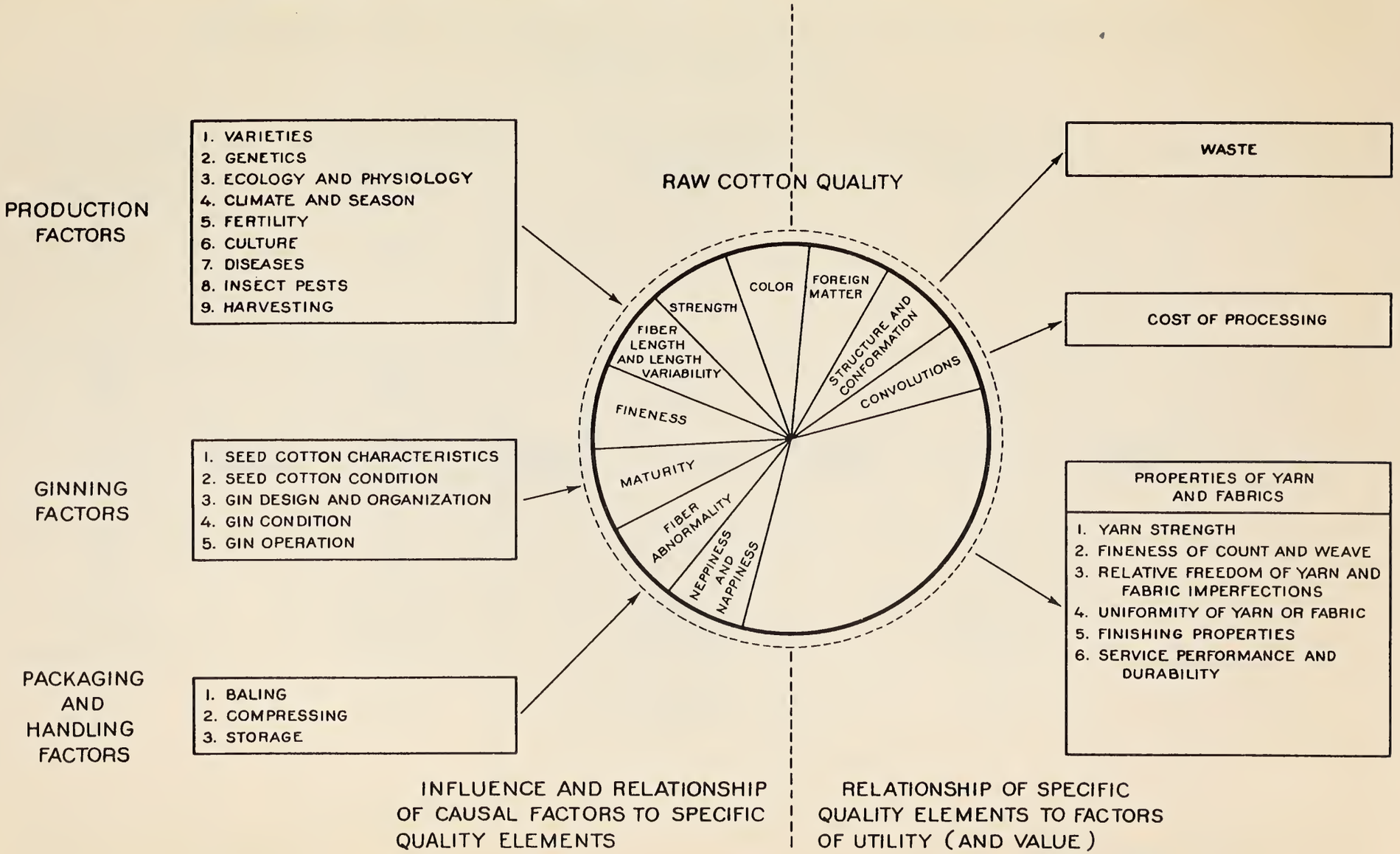
The rating of varieties and growth conditions on a basis of quality benchmarks in terms of fiber and spinning data would contribute importantly to building of a sound national cotton structure in the United States. This conclusion is further borne out by the fact that various foreign cotton producing countries have adopted this method of approach for developing their national cotton programs and that a number of them are making definite progress. However the carrying out in this country of the suggested studies on the quality of representative foreign cottons; of quickly testing each season certain American varieties; and of rendering routine service tests to the public could not be handled with our present laboratory personnel and facilities. Those now available are entirely utilized for the handling of work required by the regular cotton marketing, standardization, classification, breeding, and production problems.

But merely developing and disseminating the facts are not likely to affect cotton production greatly nor to increase individual farmer's incomes unless shippers and manufacturers are prepared to discriminate properly between cottons that have the properties which they desire and those that do not, and unless growers can receive proper premiums and discounts in relation to the quality of their cotton in their sales on local markets. Such discrimination is necessary to provide the needed incentive to sustain production of the desired cottons. American agriculture, therefore, needs the active help and support of the textile industry and the cotton trade if it is to set wisely the goal of quality for national and regional cotton production and if the greatest practical application is to be given to research findings and subsequent developments.

The field of scientific study of cotton quality is almost limitless. There are many complex problems and most of them have many fringes and relationships. For the most part, only the fringes have been explored to date. However, studying cotton quality from the scientific standpoint yields much that has immediate practical value and much that has more distant practical value. Comparative spinning and fiber tests of different varieties and growth conditions furnish the best known method by which answers can be supplied to many questions of immediate practical importance to cotton farmers and the cotton industry. These tests also furnish facts by which the United States can ascertain how to deliver consistently to world markets and mills better quality cotton of known characteristics.

All this means that our cotton quality knowledge must reach the fundamentals and be translated into every-day practices throughout the cotton enterprise. What has been available in the past is not good enough!

PROBLEM GROUPS IN COTTON QUALITY RESEARCH



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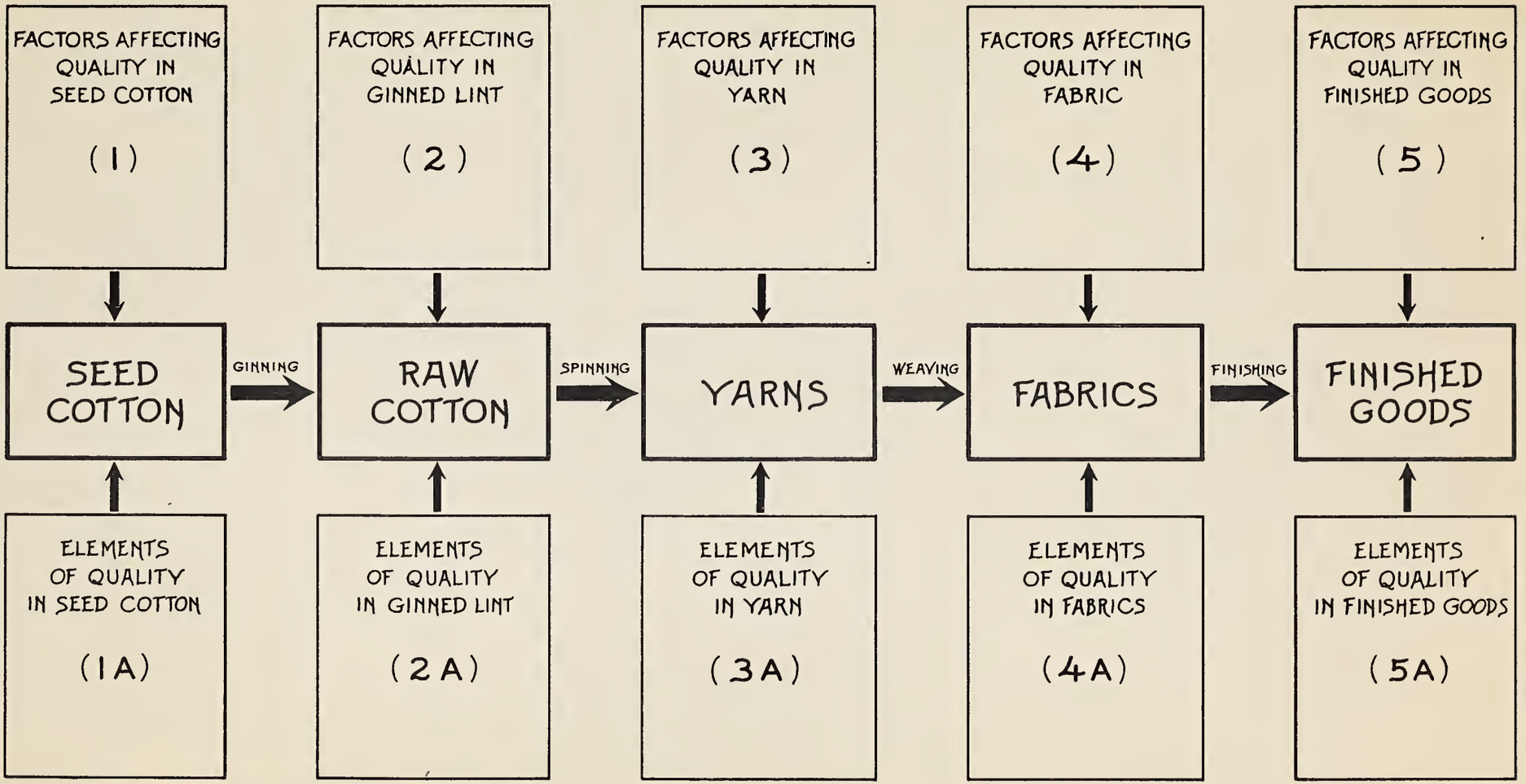
FACTORS AND ELEMENTS IN COTTON FIBER, YARN, AND FABRIC QUALITY



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